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Co-evolution of Technological Regime and Industrial Clusters: The Catching-up of Dounan's Flower Industry in China

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1. Introduction

There is wide debate about the course of technology development since 1960s', from science-push and market-pull models to non-linear and coupling models with feedback loops, from parallel lines models to systems integration and extensive networking models (Rothewell, 1992). A recent article of Schmoch(2007) empirically testified the double-boom cycles for technological development in long term observation, where the first boom can be associated with science push and the second boom with market pull. The implication of the study is that innovation policy should lay strong emphasis on long-term science development and look more closely at decreasing patent activities, which seems call back the big science times. However, it should be more careful to implement the above theory since technological trajectories may not strictly follow the way. For example, the less-developed countries usually began with market-pull technological innovation based on technology transfer or licensing due to lagging far behind in science capability. Therefore, for a specific technological economy, the evolution of technology cycles needs more reflection.

More and more researchers are interested in the technological regimes for catching up of the emerging economies, such as Korean, China, Taiwan and so on. Lee & Lim(2001) summarized three different patterns of technological catching-ups from six Korean industries, path-creating catching-up, path-skipping catching-up, and path-following catching-up. Park & Lee (2006) identified the technological regimes of Korea and Taiwai have typical characteristics of catching-up with higher appropriability and shorter technological cycle time. Mu & Lee (2005) found that the important factors

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for Chinese telecommunication industry are strategy of “trading market for technology”, segmented nature of market, knowledge diffusion from advanced sectors to less-advanced ones, and industry promotion by government. However, most of studies focus on modern industries and the technological innovation dynamics of the traditional industries, such as agricultural sectors, remain largely unexplored. Agriculture belongs to supplier-dominated industries whose innovations mostly come from suppliers of equipment and materials (Pavitt, 1984). However, the driving force for innovation from the supplier’s side is very weak in China because of the small-scale and dispersed farmers’ production. Moreover, for agricultural innovation system, research is an important component but not always the central one, while entrenched attitudes and practices, organization of rural stakeholders, and enabling environment play a more essential role in most cases (WB, 2006). To sum up, the technological innovation pattern of developing counties is completely different from general technological cycles, and the technological regimes of developing countries’ agriculture have extraordinary specificity.

Technological regimes map the properties of innovation process, the cumulativeness of technical advances, the fluidity of technological trajectory, the characteristics of industrial technology, and the nature of knowledge bases(Lee & Lim, 2001; Marsili, 2002), which also get deeply involved with a group of social factors, such as organizational structure, market powers, institutional set-up, social culture and environment, and so on. As it is indicated by Nelson and Winter (2002), technological innovation and industry structure are co-evolved. More broadly, “social technologies” support the development of “physical technologies” and conversely change itself (Nelson, 2007). Therefore, analysis on technological regime cannot deviate from its industrial system and socioeconomic environment.

This paper will reinvestigate the trajectory of technological innovation focusing on the agricultural sectors of catching-up economy with the emphasis on the co-evolution of technological regime and industrial clusters. Dounan’s flower industrial clusters of south west China are chosen as a specific case for analysis because it began from zero and now turns to be the be the largest flower industrial clusters of Asia with more than 30 new flower varieties with independent intellectual property right in 25 years. A reverse double-boom evolutionary model will be developed to explore the formation of Dounan’s flower industrial clusters and the dynamics of its technological innovation. It seeks to answer the following questions: what are the main characteristics of its technological innovation as the growth of industrial clusters; why Dounan’s flower industrial clusters could smoothly evolve and catch up while others eventually erode; what are the driving forces for technological trajectory moving from market-pull to technology-push?

This paper is organized as follows. Section 2 presents the reverse double-boom evolutionary model and discusses the interaction of industrial clusters development and technological regimes. Section 3 examines the catching-up process of Dounan’s flower industrial clusters based on the conceptual framework of section 2. Section 4 summarizes the main results and discusses policy implications.

2. The Reverse Double-boom Evolutionary Model

It has been increasingly realized that “follower” countries mostly lead a different development path of technology and economy with characteristics of leapfrogging or path-creating instead of following that of the developed countries. It is difficult to find evidence in developing counties that the technological and economic development is driven first by science-push forces and then by market-pull forces. On the contrary, in developing economies, science-push and market-pull forces are interacted in whole process and market-pull force has even overwhelming effects at the beginning. Liu & Wang (1999) justified that technological innovation of China were dominated by demand-pull in term of independent innovation. “Inverted linear model” is proposed to explain the specificity of less-developed counties, which is first economic development and then technology improvements. Bernardes & Albuquerque (2003) emphasized on science and technology interaction for less-developed catching-up rather than simple linear model or inverted linear model.

Mazzoleni & Nelson (2007) pointed out that public research institutions play a critical role in catching-up. Most catching-up economies enhance public research investment and give priority to high-tech industry to accelerate science and technology development at early stage. However, technological regimes of less-developed economies can’t begin with science push due to three main reasons. First, less-developed counties are more eager for economic development and research activities are inclined to yield to immediate interests. Second, science-based innovation depends on knowledge foundation and “absorptive capability”. The lagging behind of research infrastructure and science capability restricts less-developed counties making remarkable science-based breakthrough. Third, for less-developed counties with impatience for rapid growth, easy access to external advanced technology is a hard-to-resist temptation. Therefore, most of less-developed counties take the market dominance catching-up strategy, which rapidly increase their market share by imported technology combined with cheap local resources and labors. Consequently, their technological innovation began with market adapting and process amelioration. Nevertheless, international source of “advanced technology” is a double-edged sword. It seems that technology transfer from developed counties enable less-developed counties leap over lengthy and costly science development stage and directly enter the market-pull stage. Dependence on external technology refrain less-developed counties from technological innovation tailoring for their resource endowment and locked them in lower technology level and lower value market. The real catching-up is not the market shares catching-up but the technological capabilities catching-up associated with advanced market dominance.

We propose a reverse double-boom evolutionary model to analyze the catching-up process of less-developed countries under the co-evolution of technological regimes and industrial ecology. Unlike organizational ecology theory (Alderich & Fiol, 1994; Hannan & Carroll, 1992; etc.), technological cycle and paradigm theory (Freeman, 1991; Henderson & Clark, 1990; etc.) and institutional theory (North, 1990; Douglas, 1986; etc.), it won’t incline to emphasize on any specific factors (e.g. industry structure, technology or institution) but take them as whole to analyze their interaction behavior and co-evolution process. As described in Fig. 1, the first technological and industrial boom is led by market-pull forces and the second boom is led by science and technology-push forces.

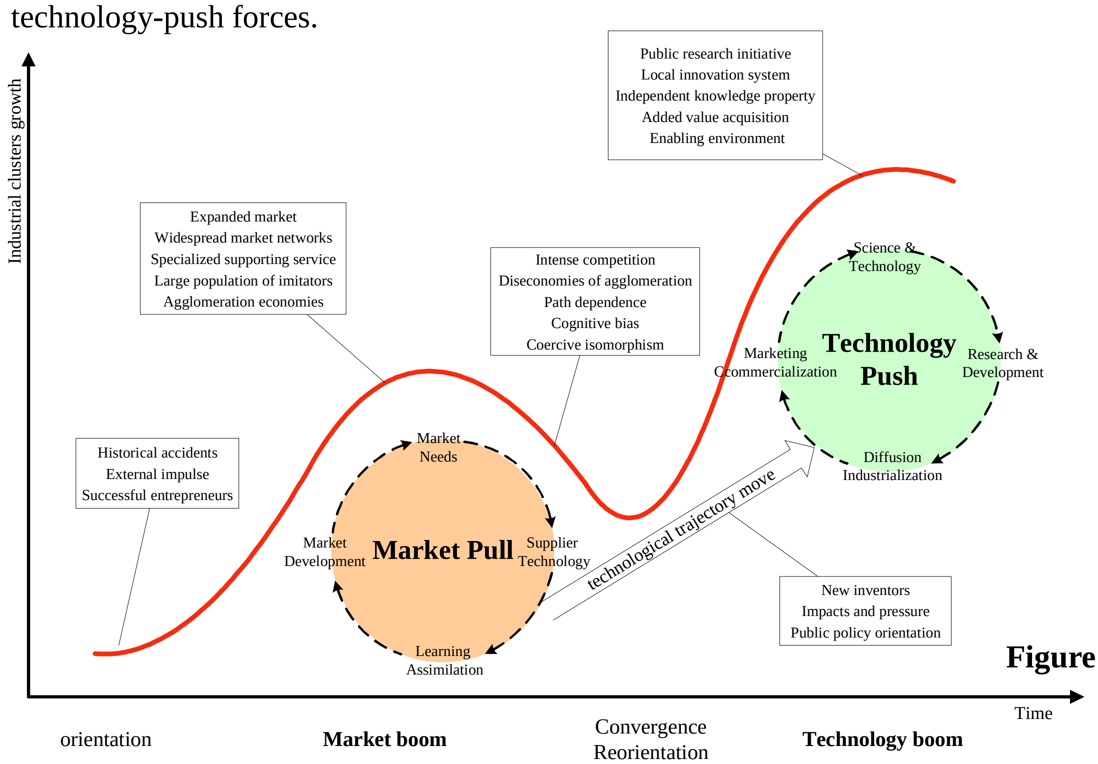

Figure 1

Evolutionary model with reverse double-boom cycles

Nobody can deny that market is an important factor for the development of both industrial clusters and technological innovation, especially in developing counties. Market promotes the development of industrial clusters and technological innovation in two ways. First, market creates demand for specific products and related industrial technology and transforms them into value, which we call market demand effect. Attracted by market opportunities, new enterprises will enter or spin-off from certain one and affiliated industries will be developed from both up and down sides. This area or region may become a hot spot for the industry and gradually agglomerate related resources, such as qualified suppliers, skilled workers, informed investors, and so on (Pouder and John, 1996). Thus, market demand effect stimulated the emergence of industrial clusters and they will flourish through recursive and cumulative development. At the same time, market demand and the formation of industrial clusters has conductive effect on technological innovation. Potential demand for new product or niche market, the interaction the main industry and affiliated industries, and industrial specilization provide abundant technological opportunities. Those first movers of new technology importation and innovation can obtain extra profits from expanded and advanced market, which will stir up new round of market driven development. As noted by Global Commodity Chain (GCC) theory, international traders will drive the local technological innovation and industrial upgrading of less-developed counties (Gereffi, 1999; Bair & Gereffi, 2001). The same things will happen when there is market segmentation in the national level and the technology of less-developed areas will improved by advanced market forces. Second, technological innovation can’t achieve in one or two days and it is a continuous knowledge accumulative process. Market provides learning, training and practicing base for technological capacity accumulation and development, which we call market demand support effect. The industrial development of less-developed areas usually began with assimilating and adapting the more or less obsolete technology of the developed areas. The technology catching-up strategy of China is called “importation, digestion & assimilation, and indigenous innovation” and “trading market for technology”. In the process, local market helps absorbing the cost of knowledge accumulation and technology innovation. Segmented market of less-developed counties provides various technological adapting opportunities. Lower-end market digests the less-advanced technological innovation products, which supports further technological innovation. Moreover, the huge market of less-developed counties is a critical resource for bargaining power (Mu & Lee, 2005). Along with the continuous technological improvement, less-developed counties will press more advanced technology transfer based on the “trading market for technology” principle. Combined with both market demand and support effect, industry will get prosperous accompanied with substantial technological innovation and in turns the development of both industrial clusters and technology helps getting access to more advanced and expanded market, which gradually accumulate growth energy and burst out the first development boom pulled by market.

Market pull boom is an important stage for the start-up and accumulation of less-developed counties. Nevertheless, under the beautiful boom, lower market value and path dependence of technology importation throw great threats and risks on their further development. Numerous factors will erode the first market pull boom and press industrial clusters convergence, such as emergence of new attractive markets, low cost of new emerging areas, depleting of local advantage resources, technology transition, and so on. To break through the ceiling of development, industrial clusters and technology strategy need to be reoriented. The reorientation usually can’t take place spontaneously but drive by a series of pro-active activities, such as consistently research efforts, public policy promotion, innovative environment construction, and so on. In recent years, most less-developed areas start a campaign of “the second start-up” to promote a transition to technological leading and innovation driven development. This reorientation will lead the development trajectory moving from market pull cycle to technology push cycle. At this stage, R & D activities are focus on basic research and frontier industrial technology rather than market adapting technology. It will create not only the new inventions and new technology but also new market and new demand. Through technology industrialization & commercialization and knowledge diffusion, science and technology innovation penetrate into industrial development and economic activities. Market dominance is more than gross amount but average profit rate, international standards and change leading accompanied with technology innovation dominance. As the engine of the industrial development and economic growth, science and technology innovation booming makes the area or regions re-thrive as a hot spot with increasingly concentration of intelligent human resources, knowledgeable venture capital, research infrastructures, new start-ups, etc., which push the development of industry to a new summit. At the same time, the new flourishing of technology based industry provide sufficient economic incentives for more advanced and specialized science and technology innovation.

The reverse double-boom model emphasizes more on the interaction between industrial structure evolution and technological innovation rather than one-fold technological innovation. Although it divides the evolution into two stages by the characteristics of the market pull and technology push, there is no separation between industry growth and technology innovation in each stages. It is their frequently interaction that boost the co-evolution of industrial clusters and technological innovation and their co-booming.

3. Stories of Dounan's flower industry catching-up

Dounan is a small village of Chenggong county of Yunan province in southwest China, 12 kilometers from Kunming city. Since commercialized flower is first introduced to Dounan in 1983, it blooms at astonishing speed. "Dounan flower" is honored as the first well-known flower trading mark of China. Kunming Dounan Flower Exchange Market and Kunming International Flower Auction Trading Center trade about one-third of fresh cutting flowers of China, pulling the development of flower industry in whole Yunan province. In 2007, the total flower planting area of Yunnan province reached 23,001 hectare and production value and gross export are respectively 8.4 billion yuan(equals to 1.22 dollar) and 85 million dollar, which made Yunnan continue to be largest flower province in China for 14 years.

This paper decomposes the development of Dounan's flower industry into five stages according to the above evolutionary model, which respectively are naissance stage, market expanding stage, fledged industry system stage, reorientation stage, and endogenous technology development stage.(See table 1)

At first stage, gladiola was introduced in Dounan by Hua Zhongyi in 1983, the deputy director of the Good Seed Factory. He learned the planting technique by himself and carried harvest flowers to Kunming agricultural market for sale. Because of its high profit and deteriorated vegetable market, flower planting spread in Dounan quickly. The mechanism of technological development was trial-and-error cumulative learning by individuals and the formation of industrial clusters was driven by successful practice and simple imitation.

Table 1 Co-evolution of technology regime and industrial clusters in Dounan

	Naissance	Market expanding	Fledged industry system	Reorientation	Endogenous technology development
Time	1983-1989	1990-1999	2000-2003	2004-2005	2006-present
Characteristics	Origination	market pull boom	market pull boom	transformation	technology push boom
Technology	Vegetable planting	Internal clusters Simple imitation	Seed suppliers Advanced buyers	Public research Enterprises	Cooperative R & D Independent intellectual

sources	experiences Trial and error		International technology grants	research Technological cooperation	property right Unique varieties registration
Industrial structure	Individual farmers	Dispersed farmers and specialized flower delivery	Dispersed farmers Specialized market Leading firms	Purposeful association Vertical and horizontal linkage	Self-organized farmers Research-oriented firms Multidimensional networks
Public policy	none	Market construction	Infrastructure improvement Exported encouragement	Research support International cooperation Brand building	Intellectual property right protection New varieties development Exported oriented policy
Collective action	Mutual help within community	Experiences exchange Jointly buying and market developing	Frequently vertical and horizontal interaction	Governmental supported association	Stakeholders alliance Collaborative research Exported oriented collaboration

The mutual reinforcement of market expanding and matured industry system lead the industrial clusters into a self-organized cumulative growth, which fueled the market-pull innovation cycle. As Lu Cuihua delivered the first batch of flower to Shanghai in 1993, local farmers were attracted to flower delivery and hundreds of flower businessmen all over the country swarmed into Dounan. Kunming Dounan Flower Exchange Market and Kunming International Flower Auction Trading Center were established respectively in 1998 and 2001, which further expand the flower trading and market networks. Market networking opened the national flower market for Dounan, which opened up the possibilities for significant economies of scale and scope and provided opportunity for specialization so as to promote the development of supporting service system. As a result, flower industrial clusters came into being. Local government also made great efforts to promote its development. In 2002, Yunnan provincial government released Suggestions on Promoting Flowers Industry Upgrading. Yunnan Flower Association was established by government in 1997 to support the development of flower industry. Combined the evolutionary mechanism of industrial clusters with public policy support, Dounan flower industrial clusters were upgraded rapidly. Up to 2002, nearly 300 flower varieties were exchanged at Dounan flower market and 1325 hektare of flower greenhouse were reconstructed in Chenggong County. Flower related techniques are continuously advanced to improve flower quality, such as engrafting, raising flower seedlings, storage and packing for fresh-keeping, and so on. More than 20 flower cooperatives were established and self-organized to integrate dispersed small-scale farmers and improve their production. These developments enabled Dounan access to larger market and exported to east and south Asian counties, which stimulated another round of improvement by new added value chain. As it noted by Haiyu horticulture Ltd., although they paid more than 3 million grant fees for new varieties, it is worth for that because they learned advanced technology and international flower information from foreign suppliers, which enable them access to international market. To enhance their technological capacity, flower farmers and enterprises also seek support from Kunming Institute of Botany of Chinese Academy of Science (CAS) and Flower Institute of Yunnan Agricultural Academy, which accelerate and strengthen their learning and assimilating related technology. At this stage, technology primarily depended on external suppliers and buyers, first from Shanghai and Guangdong provinces and then from foreign counties, while technological innovation occurred mainly in term of incremental improvement.

In 2003, Dounan's flower suffered the historical lowest price. Squeezing by Vietnamese cheaper roses and increasing cost for flower variety grant, Dounan's flower industry seems stick into "sandwich" situation. For example, the international grant fee for roses is about 0.8 dollar per plant, which will account for 1/5 of its total price per branch. A series of public policies orientated to research and development came into force, which initiated the technological trajectory move from passive market-pull to pro-active technology-push. Yunan provincial government issued "Suggestions on Quickening the Development of Export Oriented Flower" in 2006 and "Statute for Protection of New Flower Variety of Yunnan Province" is getting into the last stage of constitution to solicit comments from departments. Public finance of Yunan province invest 10 million per year in new variety development, market extension, training and international communication from 2003 to 2007. Moreover, Public research institutions have been enhanced, college city are under construction for concentrating intellectual capital, and the construction of Yunnan Flower Spark Industrial Belt proceed in an all-round way. Under the support of provincial government, the development of indigenous technology capability started from two ways in Dounan. First is to assimilate foreign technology and adapt it to local conditions. Flower leading enterprises made great efforts on the self-breeding of lilium seed in cooperation with Kunming Institute of Botany of CAS, Flower Institute of Yunnan Agricultural Academy, Biological Science Institute of Yunan University, and Yunan Agricultural University. In 2007, self-breeding lilium seed reached 20 million and the first 1 million of lilium seeds were planted in Beijing. Second is to develop unique technology and flower varieties by making full use of local diversified plant resources. Under the support of local government, Kunming Institute of Botany of CAS researched on the industrialization of wild flowers since 1996. Over 10 varieties of unique wild flower in Yunnan are domesticated and successfully sale on market. Up to January of 2008, new flower varieties with independent intellectual property right raised to 31, accounting for 70% of that of national cutting flowers. There are 20 more varieties are applying for new variety rights. Moreover, the reserved new varieties exceed 1000 in research institutes and flower enterprises. Dounan flowers industrial clusters are transited from technology dependence to endogenous technology development. Technology pushed innovation is booming and the flower industrial clusters are getting into a stage of technology driven development. An increasing amount of self-property flowers export to technology exported counties, such as Netherlands, France, Japan, and so on. Thus, Dounan flower clusters are establishing technology advantage, which in turn enhances its market dominance.

4. Concluding remarks

It suggests that the co-evolution of industry and technological regime of less-developed counties present obviously reverse double-boom cycles characteristics with technology-push followed by market-pull. The dynamism of industrial clusters and the catching-up of technology and economy are largely determined by whether they could get cross the critical threshold and jump to the technology-push cycle. The experience of Dounan's flower industry indicate that innovation-oriented public policy, universities and public research institutes, leading enterprises' innovation efforts, cooperation and collaboration, and market pressure plays important roles in the critical transformation.

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